EFFECT OF AREAWISE VARIATION IN BUFFALO HIDE ON THE RATE OF TANNING AND ON THE PROPERTIES OF SOLE LEATHER

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The rate of vegetable tanning as was evidenced from the rate of increase in T_s and fixed tan of pelt during tanning was found to be influenced by areawise variation in buffalo hide. The tanning time required to attain the maximum T_s varied from 6 days (final strength — 30°Bk) in thinner flank areas near the foreleg to 12 days (final strength — 80°Bk) in thicker butt areas. During early stages of tanning the fixation of tannin was found to be affected by locational variation and a similar trend of variation was noted as in case of T_s. Thickness variation in buffalo hide appeared to have good correlation with the rate of tanning.

Leather yield, was found to vary in different locations of the hide. Areawise variation in hide also influenced physical properties of the leathers. Water absorption of leather varied significantly from the butt to the shoulder and belly area. Apparent density of the leather was affected only slightly. Apparent density of acetone dried delimed pelt appeared to have no direct correlation with that of finished leather. Abrasion resistance and tensile strength also varied in different areas of the leather. These variations in rate of tanning, leather yield and physical properties of vegetable tanned leathers are probably caused by both thickness and structural changes throughout the hide.

Based on the results obtained the leather making potentiality of different areas of buffalo hide for making sole and industrial leathers has been discussed.

It is well recognised that hides are not uniform in quality and vary in respect to thickness, structural characteristics and chemical composition in different locations of the hide. Such variations in hide naturally influence the processing and the properties of vegetable tanned leather. The effects of such areawise variations in steer hide on processing[1] and on properties of leather[2-5] have been studied earlier; but to obtain a comprehensive view about the trend and extent of such variations in case of buffalo hide, further investigations were felt necessary. The effect of locational variation in buffalo hide on the rate of tanning, leather yield and certain physical properties of the finished leather is discussed in the present communication.

Materials and methods

Procedure for vegetable tanning: The tanning procedure has been described in detail in a previous publication.[6] In brief, well soaked buffalo hide was limed for 7 days, fleshed, washed and then delimed completely with ammonium sulphate. Tanning started in 10°Bk liquor made up of spray dried mimosa extract. After every alternate day the pelt was treated with fresh liquors of increasing strength of 20°, 30°, 40°, 60°, 80° and 100° Bk. Tanning was done in the laboratory (30°C ± 2°) at the normal pH of the tan liquors. After tanning the leather was washed well and then bleached, loaded, oiled, well set and dried. The leather was then finished and rolled.

Rate of vegetable tanning: Rate of tanning was determined by measuring the rise in shrinkage temperature and estimating the fixation of tan at regular intervals during tanning. Methods for the determination of Ts and fixed tan have been reported earlier.[6]

Thickness of pelt: Thickness of delimed pelt was measured by a thickness gauge and is expressed in mm.

Physical properties: Water absorption was measured by the Kubelka method; apparent density was determined by the mercury displacement method and abrasion measured by an abrasion tester (American Instrument Co., Silverspring, U.S.A.) after 400 revolutions. Tensile strength was determined by an Avery tester (Type 6101).

Results

A freshly slaughtered buffalo hide was washed to remove blood etc., green fleshed and then cured by wet salting. After piling for one week the hide was soaked, limed, delimed completely and then cut into two sides. Samples were then cut from the right hand side which was divided into three segments A, B and C in lines parallel to backbone (Fig. 1). Segment A was then divided into 10 pieces, segment B into 8 pieces and segment C into 7 pieces. The entire side was thus divided into 25 pieces each measuring roughly 28 × 18 cm. These samples were utilised in studying the rate of tannage based on the determinations of Ts and fixed tan at regular intervals during tanning. The data obtained are presented in Fig. 1 and Table 1.

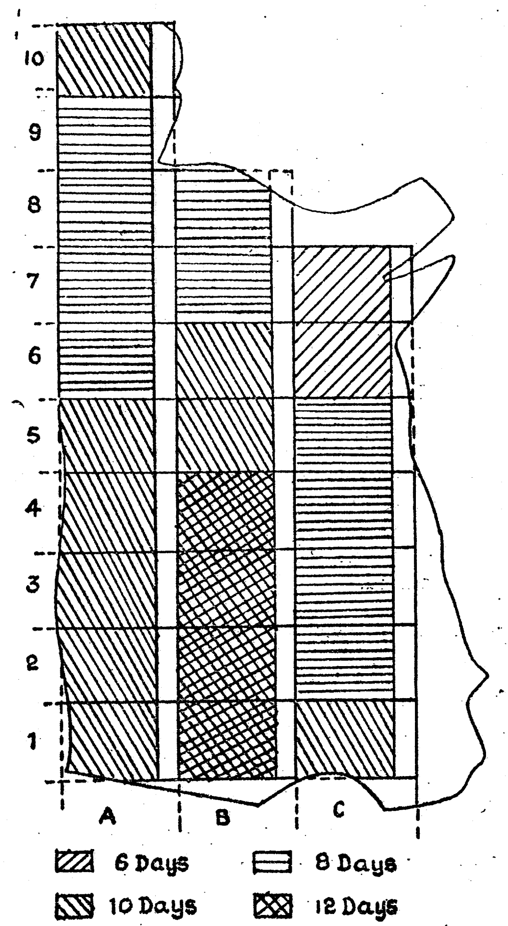


FIG. 1. Sampling positions in one side of the buffalo hide and the time taken for struck through of the pelt in different locations

Table 1

EFFECT OF AREAWISE VARIATION IN BUFFALO HIDE ON THE RATE OF VEGETABLE TANNING AS DETERMINED BY FIXATION OF TANNIN

(% fixed tan on dry weight)

Location in hide	Strength (°Bk) of tan liquor Duration of tanning in each liquor 2 days						
	10 *(2)	20 (4)	30 (6)	40 (8)	60 (10)	80 (12)	1000 (14)
A1	13·5	26·1	29·6	34·9	43·9	47·1	48·2
A2	14·2	30·5	35·6	38·4	44·3	46·4	51·0
A3	14·0	26·0	30·4	36·0	45·1	46·1	50·7
A4	11·0	24·0	32·8	39·1	44·2	47·2	50·0
A5	11·3	27·9	36·6	39·8	43·2	48·2	51·0
A6	16·2	30·5	37·9	41·7	44·9	47·5	49·8
A7	18·6	31·4	38·1	41·8	44·8	48·9	49·1
A8	19·6	28·7	34·8	39·6	45·0	49·0	51·3
A9	18·5	31·6	34·9	40·7	43·3	49·4	50·9
A10	17·7	28·0	30·1	38·6	43·5	48·9	49·5
B1	14·6	23·2	25·9	37·2	43·7	46·7	48·5
B2	15·8	21·8	24·7	38·4	43·2	47·3	47·5
B3	14·6	26·8	29·3	38·4	43·3	46·0	47·3
B4	14·1	24·0	27·0	38·1	40·5	46·1	48·0
B5	11·0	22·8	29·9	36·8	43·4	46·7	50·0
B6	16·4	26·2	34·5	38·4	46·0	48·9	50·2
B7	17·6	30·7	37·7	40·7	45·3	47·1	49·4
B8	16·7	31·8	37·8	39·9	45·3	49·1	49·7
C1	16·6	25·2	34·9	36·9	46·1	48·3	50·2
C2	20·7	28·8	34·8	40·9	47·6	47·7	49·9
C3	19·0	23·1	32·8	42·9	45·9	47·7	50·5
C4	16·0	25·4	36·0	41·9	46·4	50·2	52·5
C5	22·7	25·1	38·1	42·2	46·7	48·7	50·7
C6	20·4	33·6	39·9	43·3	47·5	49·9	51·1
C7	24·7	34·7	41·2	46·5	48·6	49·7	51·0

* Figures in the Parenthesis indicate total period of tanning in days.

It is apparent from Fig. 1 that the tanning time required to get maximum Ts or for striking through of the pelt gradually decreases in each of the segments from the tail end of the hide to the neck end except in position 10A. The extent of variation throughout the side is quite appreciable and ranges from 6 to 12 days. The completion of tannage from chemical crosslinkling point of view as well as the rate of tanning appeared to be most rapid in sampling positions C6 and C7 and rather slow in positions B1, B2, B3 and B4.

According to fixed tan data presented in Table 1, the tanning rate appears to be comparatively rapid in samples A6 to

Table 2

EFFECT OF THICKNESS AND STRUCTURAL VARIATION IN BUFFALO HIDE ON THE RATE OF TANNING AS DETERMINED BY THE RISE IN T_s (°C)

Location in hide	Delimed pelt	Strength of tan liquor (°Bk) Duration of tanning in each liquor 3 days						
		10 *(2)	20 (4)	30 (6)	40 (8)	60 (10)	80 (12)	100 (14)
B5	0	1·5	6·5	15·5	23·5	22·5	20·0	18·0
B6 (Split)	0	5·5	14·5	25·0	23·0	21·5	19·5	18·5
C6	0	5·5	15·5	24·0	22·5	21·0	18·5	17·5

* Figures in the parenthesis indicate total period of tanning in days.

A9 in segment A, in samples B6 to B8 in segment B and in samples C5 to C7 in segment C during early stages of tanning (upto 8-10 days). The rate of tannin fixation is most rapid in samples C6 and C7 and comparatively slow in samples B1 to B5.

The influence of thickness and structural variation on the rate of tanning was examined in a separate experiment. Three samples were taken from a limed buffalo pelt from positions identical with B5, B6 and C6 (Fig. 1). Samples B6 and C6 were split to the same thickness (5 mm). Sample B5 was not split (6.2 mm). These samples were then delimed and tanned as usual and the rate of tanning was determined from the rise in Ts. Results obtained are presented in Table 2.

The time taken for maximum T_s does not differ considerably between two positions (ie., B6 and C6) having the same thickness but structural variation (Table 2). On the other hand, it differs considerably when the thickness varies having roughly the same structure (i.e., B5 and B6).

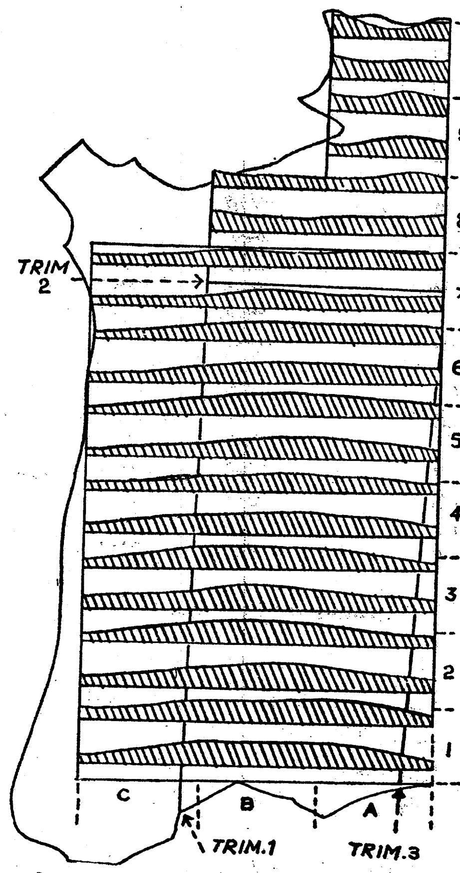


FIG. 2. Variation in thickness (mm.) in different areas of delimed pelt (actual dimension)

Table 3

APPARENT DENSITY OF ACETONE DEHYDRATED DELIMED PELT

Sample No.	Segment A	Segment B	Segment C
1	0·63	0·72	0·85
2	0·63	0·68	0·83
3	0·66	0·70	0·87
4	0·66	0·66	0·78
5	0·67	0·69	0·79
6	0·65	0·66	0·91
7	0·71	0·72	0·89
8	0·79	0·75	
9	0·78		
10	0·72		
Average	0·69	0·70	0·85

Small strips of pelt were cut from each of the samples (white portions in Fig. 1) and dehydrated by treating with increasing concentrations of acetone. The apparent density of these dried pelt pieces was determined and is reported in Table 3.

Apparent density of acetone dried delimed pelt samples seems to increase slightly from the tail end in segment A, but the extent of variation is not very significant in segments B and C.

The left hand side of the hide was cut into 25 identical samples as in right side and the samples were used for measuring thickness variation throughout the side. Thickness was measured in 12 positions along the breadth of the side and in 20-14 positions throughout the length. The variation in thickness of delimed pelt is shown in Fig. 2 and Table 4.

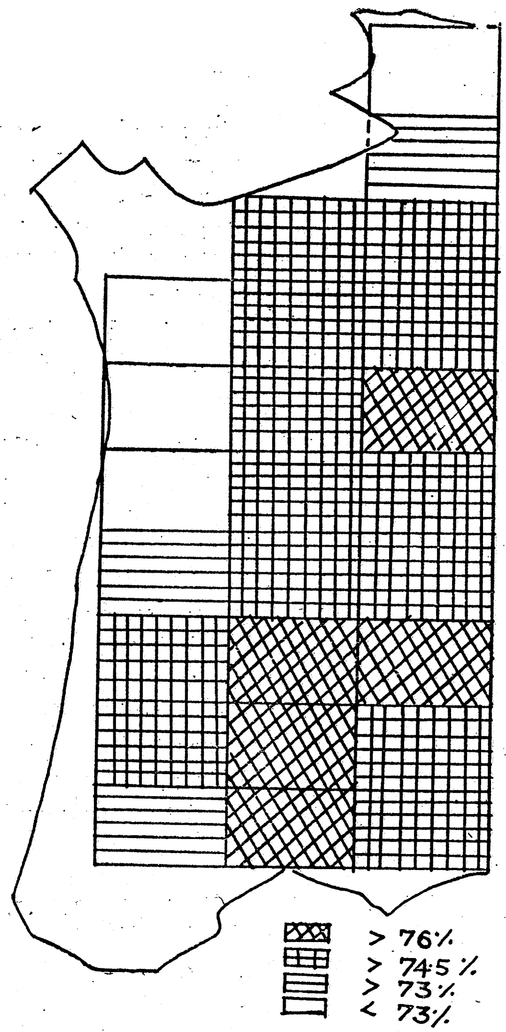
An analysis of the average values for thickness (average of nine readings) in each sample shows that thickness of the pelt gradually decreases from the tail end towards the neck in segments B and C. But in segment A, there is not much variation in samples A1 to A6, then the thickness decreases in samples A7 and A8 and again increases in samples A9 and A10. These samples were then tanned into sole leather and determinations made of the weight yield as well as certain physical properties. The variation in weight yield of finished leather in different locations of the side is shown in Fig. 3.

It is evident from Fig. 3 that leather yield (weight) varies to some extent depending on the area of the hide. The extent of variation in weight yield ranges from 71.6 to 77.4% (on delimed pelt weight). For a better understanding the entire range of variation has been divided into 4 groups. The trend of variation between the samples of each segment does not appear to be quite regular as in case of rate of tanning. But it is quite apparent that thinner samples

Table 4

AVERAGE THICKNESS (MM) OF DELIMED PELT IN DIFFERENT SAMPLING POSITIONS

Sample No.	Segment A	Segment B	Segment C
1	4·53	5·42	3·94
2	4·44	5·83	3·70
3	4·43	5·91	3·88
4	4·38	5·13	3·53
5	4·70	4·92	3·18
6	4·57	4·59	2·76
7	3·67	3·83	2·46
8	3·16	3·48	
9	3·89		
10	4·67		
Average	4·24	4·89	3·35



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e.g., C7, C6 and C5 have given lesser yield and the thicker samples B1, B2 & B3 have produced higher weight yield of leather. Sample 10A, although thicker, has however recorded less weight yield.

Leather samples from different locations were tested for physical properties like water absorption, apparent density, abrasion and tensile strength; the data obtained are given in Table 5.

In samples of segment A, water absorption does not differ much between A1 to A6 but appears to be more in samples A7 to A10. In samples of segment B, water absorption gradually increases from B1 to B8 in three stages and in samples of segment C water absorption varies slightly in samples C1 to C5 but increases considerably in C6 and C7.

Apparent density of the samples of segment A varies slightly with a tendency to diminish in value from the tail to the neck end. Samples in segment B have roughly the same apparent density; in segment C it varies to a small extent.

Abrasion in samples of all the segments varies to a certain extent. Abrasion resistance appears to be more in samples A1 and A2 in the butt area and less in samples A9, A10 in the shoulder and C3 in the belly area.

Areawise variation in hide also influences the tensile strength of sole leather and particularly in samples of segments A and C.

Discussion

Besides the extent and trend of variation in the rate of tanning and in other properties of vegetable tanned leather between the samples of each of the segments A, B and C, the difference between the average values of the samples in the three segments may also provide further information about the leather making properties of diffrent segments and will be dealt with in due course.

Table 5

EFFECT OF AREAWISE VARIATION IN BUFFALO HIDE ON CERTAIN PHYSICAL PROPERTIES OF SOLE LEATHER

Location in hide	Water absorption (%) ½ hr.	24 hr.	Apparent abrasion density (inch/400R)		Tensile strength (lb/sq. inch)
A1	33·6	42·2	0·92	0·064	4889
A2	34·7	44·5	0·91	0·063	7008
A3	35·6	41·4	0·88	0·079	5786
A4	42·4	48·6	0·90	0·071	5594
A5	38·2	43·4	0·89	0·074	5375
A6	43·1	48·7	0·87	0·069	5341
A7	44·2	53·2	0·85	0·075	5880
A8	40·1	52·2	0·87	0·079	4049
A9	38·9	54·5	0·88	0·086	4360
A10	39·9	56·8	0·81	0·085	3957
Average	39·1	48·55	0·88	0·075	5224
B1	34·1	42·4	0·92	0·071	5780
B2	35·5	42·1	0·89	0·075	5382
B3	34·0	43·4	0·91	0·082	5927
B4	37·8	47·2	0·91	0·067	5043
B5	41·0	47·4	0·91	0·082	5039
B6	35·5	47·0	0·90	0·072	6064
B7	39·3	48·0	0·90	0·070	5672
B8	38·3	49·5	0·91	0·078	5079
Average	36·9	45·9	0·91	0·075	5498
C1	39·7	57·8	0·87	0·074	5471
C2	36·8	56·8	0·88	0·075	4248
C3	41·9	53·7	0·83	0·090	4962
C4	50·2	61·0	0·87	0·080	4455
C5	44·0	56·2	0·83	0·073	5430
C6	52·7	64·6	0·84	0·073	5955
C7	53·6	65·6	0·85	0·63	5788
Average	45·6	58·7	0·85	0·078	5184

* Average of two readings.

Fig. 1 gives a topographical picture of the variation in tanning time required for the completion of tannin penetration and of crosslinking formation in different areas of the hide during tanning. It is difficult to compare the data on tannin fixation (Table 1) between the samples of each segment but an analysis of the data broadly shows certain variations in tannin fixation and the trend of variation in tannin fixation agrees with the trend as indicated by Ts data. The average values for Ts and fixed tan of the samples in segments A, B and C are presented graphically in Fig. 4. The extent of variation in rate of tanning is quite apparent and rates are found to decrease in the following order C > A > B.

It may be noted from Table 6 that the time taken for tanning in different areas of the hide bears a good correlation with thickness variation except in positions A6 and C1. This is further supported from the data presented in Table 3.

Mitton[4] observed that water absorption varied in different locations of the leather and a higher water absorption by leather is indicative of its loose and open structure. Thus water absorption may be considered as an indirect measure of the structural characteristics. A comparison (Table 6) between the areawise variation in water absorption and the time taken for tanning obviously suggests that some broad correlation may also exist between the structural variation and the penetration of tannin. Although the rate of tanning is found to be affected more by thickness variation, the influence of structural variation cannot be ignored.

The average leather yield (weight) of the samples in segments A, B and C is found to vary and decrease in the following order: B (76.14%) > A (75.08%) > C (73.5%).

The water absorption of leather is found to vary in different locations.

Table 6

INTERRELATION BETWEEN TANNIN PENETRATION, THICKNESS AND WATER ABSORPTION

Time for maximum T_s and striking through (days)	Thickness of pelt (mm)	Water absorption after 24 hr. (%)
12	> 5	42·1 — 47·2
10	< 5	41·4 — 57·8
8	> 4	48·0 — 61·0
6	< 3	64·6 — 65·6

Comparing the average values in the three segments, water absorption appears to be the lowest in segment B; it increases slightly in segment A but to a greater extent in segment C.

Apparent density of vegetable tanned leather does not vary to a considerable extent in different areas of the hide. The variation in apparent density in between the segments is also not much although the trend of variation is in the direction B > A > C. According to Mitton[4] the extent of variation in apparent density throughout the leather was less marked than it was expected; this is because looser areas of the hide absorb more water soluble materials having roughly the same density as fibres.

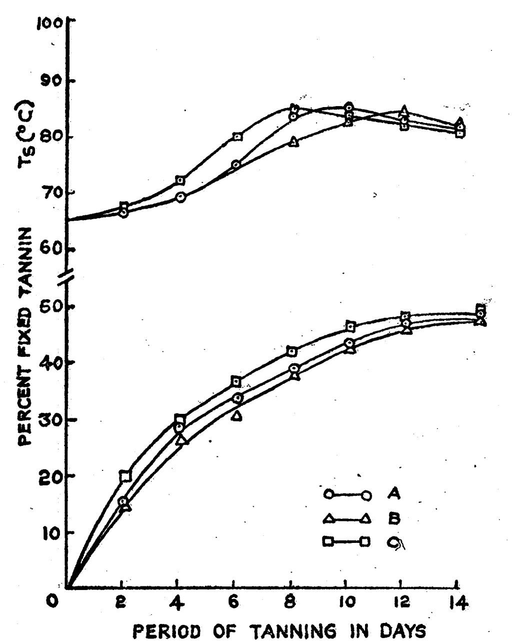

FIG. 4. Variation in the rate of vegetable tanning in different segments (average values of samples in segments A, B and C) of buffalo hide

The trend of variation in apparent density of acetone dehydrated delimed pelt is somewhat striking. Apparent density values of samples in segment C appear to be significantly higher than those of A and B whereas the samples in segment B have slightly higher apparent density than corresponding samples in segment A with the exception of B8. It may further be noted that the apparent densities of acetone dehydrated delimed pelts and of finished leathers are not directly related. It is possible that by acetone dehydration the volumes of the loose textured samples and particularly in segment C are reduced more thus leading to an increase in apparent density. On the other hand, the apparent density of finished leather depends on both the densities of fibre and tannin materials including water solubles.

Abrasion of leather is found to vary in different locations but the present data do not indicate any definite trend of variation. Average values for abrasion appear to be slightly more in segment C whereas in segments A and B they are roughly the same. Wallace[4] reported a difference of about 100% in abrasion resistance over the bend area of the hide. He further observed that abrasion was the minimum near the backbone (kidney area) and was comparatively higher in the shoulder and in the belly areas. Mitton *et al.*,[7] however measured the durability of leather in different locations of the bend area in wear trials and by determining the rate of abrasion they found that values for durability were roughly constant in most of the bend area but decreased towards the belly and shoulder areas.

Average values for tensile strength are roughly the same in all the segments.

The present investigation thus reveals that the leather making potentiality of the samples of segment C are rather poor for vegetable tanned sole leather. They are thin, give less weight, absorb more water and have slightly less apparent density and abrasion resistance. Buffalo hide may therefore be trimmed as shown in trim 1 (Fig 2). Sample A10 is found unsuitable for any good quality leather. Samples A7 to A9 and B7 to B8 are comparatively thin, less compact in structure and have comparatively more water absorption. So to produce sole leather of uniform quality and of better properties the hide may also be trimmed according to the line of trim 2 (Fig. 2). More attention is to be paid to the locational variation in hide or leather when manufacture of industrial leather from buffalo hide is concerned. The thickness of the buffalo hide in the butt area adjacent to the backbone is much less than required for making industrial leather. In order to produce uniform quality industrial leather, buffalo hide is to be further trimmed as in trim 3 (Fig. 2).

Acknowledgment

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REFERENCES

1. Holmes, N. L. & Wollenberg, H. G., *J. Soc. Leath. Trades Chemists,* 42, 268, 1958.

2. Lloyd, D. J. & Merry, E. W., *J. Int. Soc. Leath. Trades Chemists,* 21, 178, 1937.

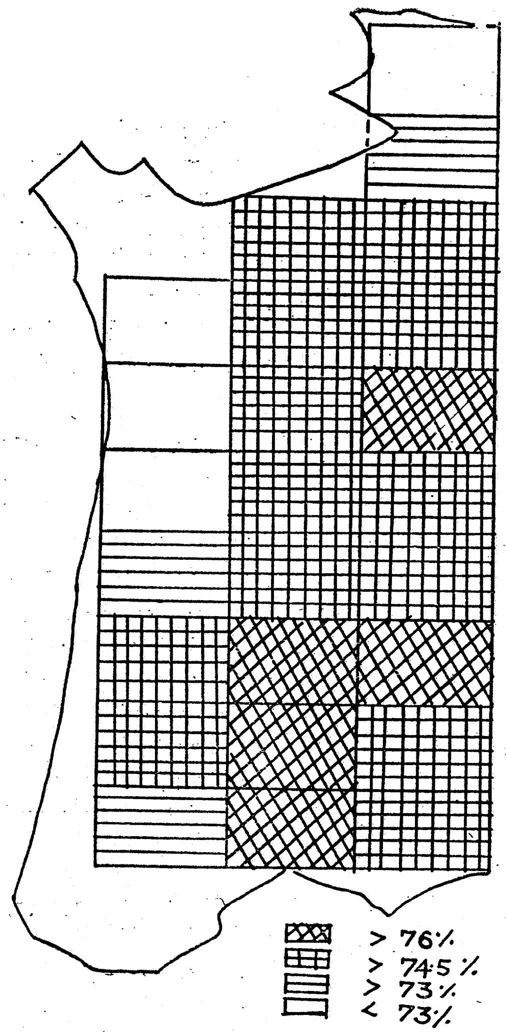
3. Edwards, R. S., *J. Int. Soc. Leath. Trades Chemists,* **16**, 292, 1932; **19**, 97, 1935.

4. Mitton, R. G., Progress in Leather Science (1920-45), B.L.M.R.A., London (1948).

5. Wallace, F. L., *J. Am. Leath. Chem. Assoc.*, **32**, 325, 1937.

6. Nandy, S. C., Khanna, J. K., & Nayudamma, Y. Paper presented in the Seminar on Biological Aspects of Leather Manufacture, Madras 1968.

7. Mitton, R. G., Millar, M. & Morgan, F. R., *J. Am. Leath. Chemists Assoc.*, **56**, 486, 1961.



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INTERRELATION BETWEEN TANNIN PENETRATION, THICKNESS AND WATER ABSORPTION

Time for maximum T_s and striking through (days)	Thickness of pelt (mm)	Water absorption after 24 hr. (%)
12	>5	42·1 — 47·2
10	<5	41·4 — 57·8
8	>4	48·0 — 61·0
6	<3	64·6 — 65·6

Comparing the average values in the three segments, water absorption appears to be the lowest in segment B; it increases slightly in segment A but to a greater extent in segment C.

Apparent density of vegetable tanned leather does not vary to a considerable extent in different areas of the hide. The variation in apparent density in between the segments is also not much although the trend of variation is in the direction B > A > C. According to Mitton[4] the extent of variation in apparent density throughout the leather was less marked than it was expected; this is because looser areas of the hide absorb more water soluble materials having roughly the same density as fibres.

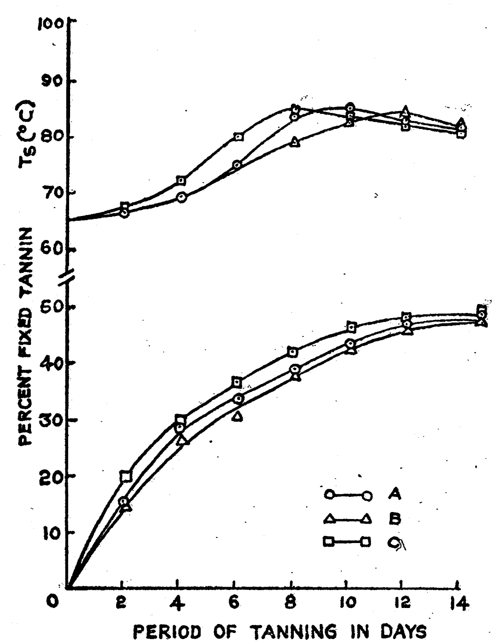

FIG. 4. Variation in the rate of vegetable tanning in different segments (average values of samples in segments A, B and C) of buffalo hide

The trend of variation in apparent density of acetone dehydrated delimed pelt is somewhat striking. Apparent density values of samples in segment C appear to be significantly higher than those of A and B whereas the samples in segment B have slightly higher apparent density than corresponding samples in segment A with the exception of B8. It may further be noted that the apparent densities of acetone dehydrated delimed pelts and of finished leathers are not directly related. It is possible that by acetone dehydration the volumes of the loose textured samples and particularly in segment C are reduced more thus leading to an increase in apparent density. On the other hand, the apparent density of finished leather depends on both the densities of fibre and tannin materials including water solubles.

Abrasion of leather is found to vary in different locations but the present data do not indicate any definite trend of variation. Average values for abrasion appear to be slightly more in segment C whereas in segments A and B they are roughly the same. Wallace[4] reported a difference of about 100% in abrasion resistance over the bend area of the hide. He further observed that abrasion was the minimum near the backbone (kidney area) and was comparatively higher in the shoulder and in the belly areas. Mitton *et al.*,[7] however measured the durability of leather in different locations of the bend area in wear trials and by determining the rate of abrasion they found that values for durability were roughly constant in most of the bend area but decreased towards the belly and shoulder areas.

Average values for tensile strength are roughly the same in all the segments.

The present investigation thus reveals that the leather making potentiality of the samples of segment C are rather poor for vegetable tanned sole leather. They are thin, give less weight, absorb more water and have slightly less apparent density and abrasion resistance. Buffalo hide may therefore be trimmed as shown in trim 1 (Fig 2). Sample A10 is found unsuitable for any good quality leather. Samples A7 to A9 and B7 to B8 are comparatively thin, less compact in structure and have comparatively more water absorption. So to produce sole leather of uniform quality and of better properties the hide may also be trimmed according to the line of trim 2 (Fig. 2). More attention is to be paid to the locational variation in hide or leather when manufacture of industrial leather from buffalo hide is concerned. The thickness of the buffalo hide in the butt area adjacent to the backbone is much less than required for making industrial leather. In order to produce uniform quality industrial leather, buffalo hide is to be further trimmed as in trim 3 (Fig. 2).

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REFERENCES

1. Holmes, N. L. & Wollenberg, H. G., *J. Soc. Leath. Trades Chemists,* 42, 268, 1958.

2. Lloyd, D. J. & Merry, E. W., *J. Int. Soc. Leath. Trades Chemists,* 21, 178, 1937.

3. Edwards, R. S., *J. Int. Soc. Leath. Trades Chemists,* 16, 292, 1932; 19, 97, 1935.

4. Mitton, R. G., Progress in Leather Science (1920-45), B.L.M.R.A., London (1948).

5. Wallace, F. L., *J. Am. Leath. Chem. Assoc.*, 32, 325, 1937.

6. Nandy, S. C., Khanna, J. K., & Nayudamma, Y. Paper presented in the Seminar on Biological Aspects of Leather Manufacture, Madras 1968.

7. Mitton, R. G., Millar, M. & Morgan, F. R., *J. Am. Leath. Chemists Assoc.,* 56, 486, 1961.